[*Japanese text, sheet 303 (1), bibliographic section*]

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(54) An Optical Waveguide Device

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[1] *Here and below, the readings given for Japanese personal names, especially given names, should be considered unconfirmed as there are in general a number of possible readings therefor. —Tr.*

[*Japanese text, sheet 303 (1), Specification, column 1*]

SPECIFICATION

1. TITLE OF INVENTION

An Optical Waveguide Device

2. CLAIMS

(1) An optical waveguide device characterized in that a Group II-VI cubic system compound thin film is formed on an[2] ABO_3 perovskitic (where A is one [species] selected from among the group [consisting of] K, Ba, Sr, and Pb; and B is one [species] selected from among the group [consisting of] Ti, Ta, Zr, Fe, Sn and C[*illeg.*]) oxide substrate, [this thin film] having a higher optical refractive index than that of the aforesaid substrate and an optical waveguide being formed at a prescribed location on this thin film.

(2) An optical waveguide device according to claim 1 characterized in that a tetragonal crystal of the aforesaid ABO_3 perovskitic [material] is used as the aforesaid

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2 *Here and below, as legibility of Japanese text is marginal, subscripts and the like will be rendered as they appear when they can be read with reasonable confidence and will be marked* "[illeg.]" *otherwise, but poor quality of even enlarged versions of images available from JPO website makes it difficult to rule out possibility that subscripts, etc. are incorrect as reproduced here. For definitive determination of such fine lettering and numbering, a copy of the Japanese text which is better than that available from the JPO website should be consulted. —Tr.*

substrate, and a (100) face[3] of the aforesaid compound semiconductor is epitaxially grown over a (001) face thereof.

(3) An optical waveguide device according to claim 1 characterized in that a cubic crystal of ABO_3 perovskitic [material] is used as the aforesaid substrate, and a (100) face of the aforesaid compound semiconductor is epitaxially grown [*Japanese text, sheet 303 (1), Specification, column 2*] over a (100) face thereof.

(4) An optical waveguide device according to claim 1 characterized in that the aforesaid compound semiconductor comprises ZnSe, ZnTe, $ZnSe_{1-x}Te_x$ $(0 < x < 1)$, [and][4] ZnS.

3. DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an optical waveguide device in the context of an optical integrated circuit or the like, its object being to provide an optical waveguide device for guiding light waves wherein a ZnTe, ZnSe, or a mixed crystal thereof, or another such Group [*illeg.*]-VI cubic system compound semiconductor thin film [forms] a heterojunction over a substrate [comprising] monocrystalline oxide having a tetragonal or cubic structure [based on] an ABO_3-type perovskitic [material] such as $BaTiO_5$, for application in functional elements in a variety of optical integrated circuits.

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3 *Here and below, crystal orientations are represented using ordinary rounded parentheses (), regardless of usage in the Japanese text, which appears to be inconsistent and is only marginally legible in any event. —Tr.*

4 *Absence of a conjunction in the Japanese text makes it difficult to determine definitively whether species are listed in the alternative, but the absence of an alternative conjunction ("or") would normally be taken to indicate that they are* not *listed in the alternative (therefore implying "and"). —Tr.*

Conventional large-capacity optical communications systems, as they possess a variety of active and passive integrated optical circuit devices, have capabilities for guiding and carrying out processing of light waves carrying information. For this reason, research on various thin film optical waveguides and optical integrated circuits has recently been underway. Whether the aforesaid optical systems that have resulted from the research in this field to date will be successful is dependent upon development of thin film materials optimized for manufacture of devices having waveguide processing [capabilities] and possessing [*Japanese text, sheet 304 (2), Specification, column 3*] appropriate optical transmission properties.

At present, optical waveguide losses for monocrystalline thin film materials are generally low and they can be easily and cheaply manufactured into [devices] having desired properties and dimensions, and with regard to fabrication of active elements as well, [materials] well suited therefor, such as, for example, LiNbO3, GaAs - GaAlAs, and the various garnet monocrystalline thin films, are being researched, and thin film optical switches, modulators, lasers, and other such elements are being reported. However, despite such recent developmental research, there are very few monocrystalline materials suitable for optical thin film devices in terms of optical loss, modulation, and so forth. Accordingly, there is great demand for new monocrystalline materials suited to fabrication of the many varieties of active and passive elements for the aforesaid optical systems at the present time.

It happens to be the case that Group II-VI compound semiconductors display large electro-optical effect, even as compared with other semiconductors, and there are reports of optical modulators employing monocrystalline ZnSe and ZnTe plates. However, an example of a monocrystalline thin film is not to be found [among the reported devices], the only examples which exist being those in which monocrystalline thin film(s) merely [form] a semiconductor heterojunction after the fashion of ZnTe - GaAs, and because the refractive index of GaAs is larger than that of this ZnTe - GaAs, light cannot be effectively contained within ZnTe crystal

such as is suited for [use as] an optical element, and [the configuration] cannot [*Japanese text, sheet 304 (2), Specification, column 4*] be used as an optical waveguide device.

The present invention therefore employs the aforesaid ZnSe, ZnTe, [or] other such Group II-VI compound thin film crystal and forms a monocrystalline thin film of this over a monocrystalline oxide substrate possessing an ABO_3 perovskitic (where A is one [species] selected from among the group [consisting of] K, Ba, Sr, and Pb; and B is one [species] selected from among the group [consisting of] Ti, Ta, Zr, Fe, Sa and C[*illeg.*]) tetragonal or cubic system structure and having a lower refractive index than [the aforesaid compound thin film crystal], and forms an optical waveguide in the monocrystalline thin film so formed, to obtain excellent optical transmission characteristics. $BaTiO_5$ and other such perovskitic ABO_3 crystals have been the subject of conventional research as ferroelectric materials, and in particular have found practical use as ceramics because of the fact that they are substances having high melting points.

Crystallographic and optical properties of perovskitic ABO_3 crystals and cubic system Group II-VI compound semiconductor crystals will first be shown in the following table.

Remainder of [column] left intentionally blank

[*Japanese text, sheet 304 (2), Specification, column 5*]

Name of Substance	Lattice Constant	Melting Point	Refractive Index	Epitaxial Examples
ZnTe	6.10 Å	1240° C	2.68	
ZnSe	5.68	1500	2.43	
ZnS	5.50	1860	2.47	
BaT[*illeg.*]O_3	a = 3.994 Å c = 4.038	1618° C	N_a = 2.4 N_c = 2.35	ZnSe
$SrTiO_3$	a = 3.905	~2000	2.35	ZnTe, $ZnSe_{1-x}Te_x$ ZnSe
$SrZrO_3$	a = 4.099	2640		ZnTe, ZnSe
$PbTiO_3$	a = 3.904 c = 4.152			ZnSe

$BaZrO_3$	a = 4.192	2688		ZnSe, ZnTe
$SrSnO_3$	a = 4.02			ZnSe
$KTaO_3$	a = 3.989 c = 4.003	1357	2.21	ZnSe
$BeSnO_3$	a = 4.12			ZnTe

Turning now to the junction between the (100) face of the cubic system Group II-VI semiconductor crystal and the (001) face of the ABO_3-type crystal, the approximate mismatch between the lattice constant of the ABO_3-type crystal and the lattice constant of the Group II-VI semiconductor crystal is not more than on the order of 10% as calculated from this table, which is well [within the range] permitting epitaxial growth, and epitaxial growth is carried out such that an angle of 45° is formed between the ABO_3 <100> direction and the semiconductor crystal <100> direction, [*Japanese text, sheet 304 (2), Specification, column 6*] as shown in FIG. 1. In terms of crystal structure, with an ABO_3-type tetragonal crystal substrate a satisfactory epitaxially grown thin film can be obtained with the (100) face of the monocrystalline Group II-VI semiconductor over the (001) face of this [ABO_3-type tetragonal] crystal. Furthermore, with an ABO_3-type cubic crystal substrate, a most satisfactory epitaxially grown monocrystalline thin film can be obtained with the (100) face of that [ABO_3-type cubic crystal substrate] and the (100) face of the semiconductor crystal.

Furthermore, as the difference in coefficient of thermal expansion is such that [the difference in coefficient of thermal expansion] for Group II-VI semiconductor - ABO_3 crystals is less than that for Si on sapphire, which is currently being epitaxial grown successfully, melt warpage upon cooling should be small. From comparison of the refractive indices in the above table, the refractive indices of Group II-VI semiconductors are higher than those of ABO_3 crystals, permitting construction of a high-grade optical waveguide device for guiding light waves when the semiconductor film has a thickness on an order that is more or less close to the wavelength of light propagating through the thin film in an inductive mode parallel to the plane of that [semiconductor film].

It is sufficient in principle that the thin film used for the optical waveguide have a thickness on the order of the wavelength of the light propagating therethrough, and while the thickness of the thin film may be within [*Japanese text, sheet 305 (3), Specification, column 7*] the range 0.1 to 100 times the optical wavelength, the range 1 to 10 times the wavelength is satisfactory. Testing of the optical waveguide may be carried out using a well-known prismatic optical coupler and introducing laser light into the thin film as shown in FIG. 2. At FIG. 2, 1 is a substrate, 2 is an epitaxial thin film for optical waveguide use, 3 and 3' are prismatic optical coupler(s), and 4 is laser light. This method makes it possible to obtain a value for optical loss and to determine whether or not the thin film is acceptable.

Working examples of the present invention in which Group II-VI semiconductor crystal thin films are obtained by epitaxial growth on the aforesaid perovskitic ABO_3 crystals will now be described.

(1) Vapor Deposition of ZnSe on $SrTiO_3$

Vapor deposition was carried out using the (100) face of $SrTiO_3$ as substrate and monocrystalline ZnSe as vapor deposition source. [Vapor deposition] was carried out at a vapor deposition temperature of 800° C to 1000° C, with substrate temperature being varied from 200° C to 600° C. A quite satisfactory epitaxial film could be obtained at substrate temperatures 400° C to 500° C, and optical waveguide testing also [indicated] that losses [of the epitaxial films produced in this temperature range] were low.

(2) Growth of ZnSe on $SrTiO_3$ and $SrZrO_3$.

[*Japanese text, sheet 305 (3), Specification, column 8*]

Vapor phase growth was carried out with a growth apparatus as shown in FIG. 3 using the (001) face of $SrTiO_3$ as substrate. [Growth] was carried out within a quartz tube 6 within a furnace while holding the temperature of the Zn and Te source material 7, 8 [*illeg.*] constant at 490° C, the amounts of Zn and Te supplied being such that[5] the flow rate of H_2 gas was varied,[6] a growth layer from several thousand Å to as thick as 100 μ was obtained when [growth] was carried out with a substrate 9 temperature of 720° C, a H_2 primary [gas] flow rate of 200 cc/min, and Zn and Te carrier gas flow rate(s) of 50 cc/min. The growth layer was confirmed as being a monocrystalline thin film as a result of both x-ray and electron beam diffraction, a (100) face of ZnTe was [observed] to have been grown on a (001) face $SrTiO_3$ crystal, and optical waveguide testing was also satisfactory. Furthermore, when ZnTe was epitaxially [grown] on $SrZrO_3$, crystallinity of the $SrZrO_3$ base was somewhat poor, and while losses during optical waveguide testing were large as compared with those above, an epitaxially grown thin film could be obtained.

(3) Vapor Deposition of $ZnSe_{1-x}Te_x$ $(0 < x < 1)$ on $SrTiO_3$.

Vapor deposition was carried out using the (100) face of $SrTiO_3$ as substrate and $ZnSe_{0.5}Te_{0.5}$ as vapor deposition materials. Conditions were more or less identical to those at Working Example (1), and the film obtained [showed signs of] localized [*Japanese text, sheet 305 (3), Specification, column 9*] monocrystal formation, with slightly larger values being obtained for loss than at (1) during optical waveguide testing. Equivalent

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5 *Apparent significant typographical error at this location makes the intended meaning of the Japanese text unclear. —Tr.*

6 *Comma at this location in Japanese text should probably be a period. —Tr.*

values are[7] obtained for the range of x as values [obtained] with[8] $ZnSe_{1-x}Te_x$ mixed monocrystal fabrication examples.

The present invention can be applied not only to the epitaxial methods of the above working examples, but also where liquid phase, vapor phase, molecular beam epitaxy, vacuum vapor deposition methods, or the like are [employed] as epitaxial method.

The optical waveguide device of the present invention may be [used] to construct an optical modulator or optical switch exploiting characteristics possessed by Group II-VI compound semiconductors, i.e. [their] universally well-known electro-optical effect(s), as shown in FIGS. 4 and 5, or a photodetector exploiting photoconduction, as shown in FIGS. 6 and 7, or the like.

At FIGS. 4 and 5, 9 is a monocrystalline perovskitic ABO_3 substrate; 10 is a Group II-VI monocrystalline semiconductor thin film grown on substrate 9; 11 and 12 are optical waveguides formed by diffusion of impurities in this thin film;[9] 13, 14, and 15 are electrodes; optical modulator(s) shown in FIGS. 4 and 5 being constituted by application of a voltage to this electrode 14 from a power supply 16; thin films 11 and 12 forming [*Japanese text, sheet 305 (3), Specification, column 10*] directional optical coupler(s). That is, light 17 incident on waveguide 11 is modulated by the voltage applied to the electrode and is output from waveguide 12.

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7 *Change in tense as in Japanese text. —Tr.*

8 *Stricken minus sign at this location in Japanese text not reproduced here (stricken material being simply omitted here instead) because small font of subscript and identical directions of minus sign and strikethrough symbol would make for difficult legibility. Refer to Japanese text for pre-stricken content. —Tr.*

9 *Minor typographical error in Japanese text at this location (missing comma). —Tr.*

At FIGS. 6 and 7, 9, 10, and 11 indicate [elements] identical to those shown in FIGS. 4 and 5, a Schottky-barrier-type photodiode region being constituted by thin film 11 and electrodes 20 and 21. 22 and 23 are lead traces. This device detects light passing through thin film 11 at the aforesaid photodiode region.

As [described] above, the present invention makes it possible to form a Group II-VI compound semiconductor thin film on a perovskitic ABO_3 crystal insulator substrate, permitting fabrication of an optical waveguide device for guiding light waves and permitting [achievement of] a monocrystalline thin film of satisfactory crystallinity having few defects due to substrate selection or solid solution, therefore making it possible for a satisfactory thin film optical waveguide device to be obtained. That is, fabrication of optical modulators and optical switches is made possible as a result of the large electro-optical effect of Group II-VI crystals, and moreover, Schottky-barrier-type optical detectors and heterojunction-type photodiodes can be [integrated] on the same substrate, providing a valuable device [for use] as a signal processing component for [*Japanese text, sheet 306 (4), Specification, column 11*] optical communication.

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a drawing [showing] the orientational relationship at the epitaxial junction between an ABO_3-type crystal and a semiconductor layer, FIG.2 is a sectional drawing [showing] the structure of a prismatic optical coupler for optical waveguide testing, FIG. 3 is a schematic diagram [showing] the constitution of a vapor phase growth apparatus used in a working example or the present invention, FIG. 4 is a plan view of an optical modulator wherein the present invention is applied, FIG. 5 is a sectional drawing along section III - III' in FIG. 3,[10] FIG. 6 is a

[10] "FIG. 3" *in Japanese text is probably a typographical error intended to have been* "FIG. 4." —*Tr.*

sectional drawing [showing] the principal components of a photodetector wherein the present invention is likewise applied, and FIG. 7 is a sectional drawing along section V - V' in FIG. 6.

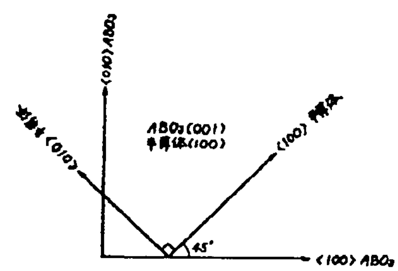
9 … … monocrystalline perovskitic ABO_3 substrate; 10, 11 … … Group II-VI monocrystalline compound semiconductor thin film.

Name of agent: Toshio NAKAO, Patent Attorney, and one other

[*Japanese text, sheet 306 (4), Drawings*]

FIG. 1

第 1 図



[left] <010> Semiconductor

[center] Semiconductor (100)

[right] <100> Semiconductor

FIG. 2

第 2 図

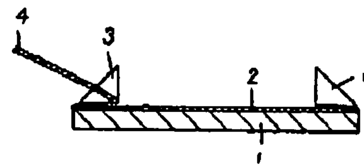


FIG. 3

第 3 図

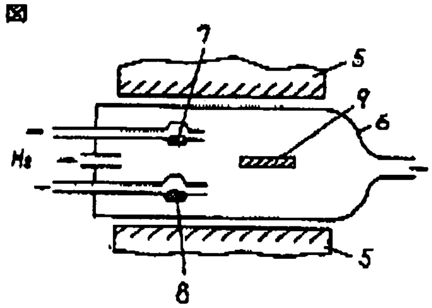


FIG. 4

第 4 図

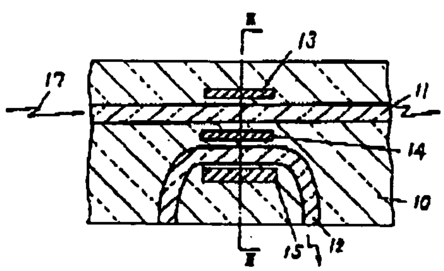


FIG. 5

第 5 図

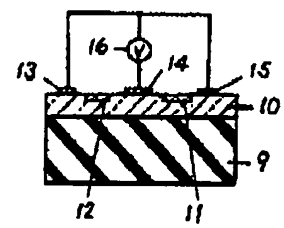


FIG. 6

第 6 図

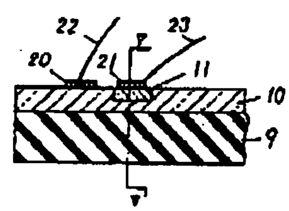
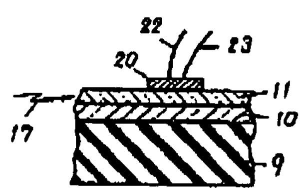


FIG. 7

第 7 図



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（全 4 頁）

⑭光導波装置

㉑特　　願　昭51—5610
㉒出　　願　昭51(1976) 1月20日
㉒発 明 者　服部勝治
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明　　細　　書

1、発明の名称

光導波装置

2、特許請求の範囲

(1) ABO₃ペロブスカイト型（ただしAはK,Ba,Sr,Pbの群より選択された1つ、BはTi,Ta,Zr,Fe,Sn,Ceの群より選択された1つ）酸化物基板上に、上記基板より光学的屈折率の大きなII−VI族立方晶系化合物薄膜を形成し、この薄膜の所定部に光導波路を形成したことを特徴とする光導波装置。

(2) 上記基板として上記ABO₃ペロブスカイト型の正方晶結晶を用い、その（001）面上に上記化合物半導体の｛100｝面をエピタキシアル成長させたことを特徴とする特許請求の範囲第1項に記載の光導波装置。

(3) 上記基板としてABO₃ペロブスカイト型の立方晶結晶を用い、その｛100｝面上に上記化合物半導体の｛100｝面をエピタキシアル成長させたことを特徴とする特許請求の範囲第1項に記載の光導波装置。

(4) 上記化合物半導体がZnSe，ZnTe，$ZnSe_{1-x}Te_x$（$0<x<1$），ZnSよりなることを特徴とする特許請求の範囲第1項に記載の光導波装置。

3、発明の詳細な説明

本発明は光集積回路等における光導波装置に関し、BaTiO₃のようなABO₃形ペロブスカイト形正方晶あるいは立方晶構造をもつ酸化物単結晶を基板としてその上にZnTe，ZnSe、あるいはその混晶などのII−VI族立方晶系化合物半導体薄膜を異種接合して光導波のための光導波装置を提供し、種々の光集積回路の機能素子への応用に供することを目的とする。

従来の大容量光学通信システムは種々の能動的及び受動的集積光学回路装置を有し、情報をのせた光波を導き処理を行なう機能をもつものである。最近はそのために種々の薄膜光導波路、光集積回路の研究がなされている。現在までのこの分野の研究により前記光学システムが成功するかどうかは、適当な光伝送特性を持ち、導波処理を有する

装置の製造に最適な薄膜材料の開発に依存する。

現在単結晶薄膜材料は一般的に光導波損失が小さく、希望する性質と形状の製造が簡単で安価であり、能動素子の作製についてもよく適応できる例えば$LiNbO_3$, $GaAs-GaAlAs$,各種ガーネット薄膜単結晶などが研究され薄膜光スイッチ，変調器，レーザーなどの素子が報告されている。しかし、これらの最近の開発研究にもかかわらず光の損失，変調等の点で光薄膜装置に適する単結晶材料はまれである。したがって今日前記光学システムで多くの種類の能動的，受動的素子の作製に適する新らしい単結晶材料に対する要求が高まっている。

ところで、II－VI族化合物半導体は半導体の中でも電気光学効果が大きく、ZnSe, ZnTe単結晶板を使用した光変調器の報告がある。しかし薄膜単結晶の例はみあたらず、単に$ZnTe-GaAs$のごとく半導体ヘテロ接合として単結晶薄膜が作成された例があるのみで、この$ZnTe-GaAs$は$GaAs$の屈折率の方が大きいため光素子用に適したZnTeの結晶に光を有効にとじ込めることができず、光導波装置として用いることはできない。

そこで、本発明は上記ZnSe, ZnTe等のII－VI族化合物半導体結晶を用いるとともにこの単結晶薄膜をそれよりも低い屈折率を有するABO_3ペロブスカイト型（ただし、AはK，Ba，Sr，Pbより選ばれた1つ、BはTi，Ta，Zr，Fe，Sn，Crより選ばれた1つ）正方晶あるいは立方晶系構造をもつ酸化物単結晶基板上に形成し、ここで形成した単結晶薄膜に光導波路を形成することによりすぐれた光伝送特性を得るものである。$BaTiO_3$などのペロブスカイト型ABO_3結晶は従来強誘電体材料として研究され、特に高融点物質であるためセラミックとして実用化されている。

まず、ペロブスカイト型ABO_3結晶と立方晶系II－VI族化合物半導体結晶との結晶学的および光学的性質を次表に示す。

以　下　余　白

物質名	格子定数	融点	屈折率	エピタキシャル例
ZnTe	6.10Å	1240℃	2.68	
ZnSe	5.68	1500	2.43	
ZnS	5.60	1850	2.47	
$BaTiO_3$	a=3.994Å c=4.038	1618℃	N_e=2.4 N_o=2.35	ZnSe
$SrTiO_3$	a=3.905	~2000	2.35	ZnTe, $ZnSe_{1-x}Te_x$ ZnSe
$SrZrO_3$	a=4.099	2640		ZnTe, ZnSe
$PbTiO_3$	a=3.904 c=4.152			ZnSe
$BaZrO_3$	a=4.192	2688		ZnSe, ZnTe
$SrSnO_3$	a=4.02			ZnSe
$KTaO_3$	a=3.989 c=4.003	1367	2.21	ZnSe
$BaSnO_3$	a=4.12			ZnTe

さて、立方晶系II－VI族半導体結晶の（100）面とABO_3型結晶の（001）面との接合をみると、この表から計算されるABO_3型結晶の格子定数とII－VI族半導体結晶の格子定数のズレの程度は10%程度以下となって充分エピタキシャル成長が可能で、ABO_3<100>方向と半導体結晶<100>方向とは第1図に示すごとく45°の角度をなしてエピタキシャル成長する。結晶構造的にはABO_3型正方晶結晶基板の場合、この結晶の（001）面上にII－VI族半導体単結晶の（100）面とで良好なエピタキシャル成長薄膜を得ることができる。またABO_3型立方晶結晶基板の場合はその(100)面と半導体単結晶の（100)面において最も良好なエピタキシャル成長単結晶薄膜を得ることができる。

また熱膨張係数の差はII－VI族半導体－ABO_3結晶のそれは現在エピタキシャルで成功しているサファイア上のSiのそれに比して小さく冷却による熱歪としては小さくなる。上記表の屈折率比較からII－VI族半導体はABO_3結晶よりも屈折率が高く、半導体膜がその平面と平行な誘導モードで薄膜中を伝播する光の波長にほぼ近いオーダーの大きさの厚みを持つ時、高品位な光導波のための光導波装置を構成することができる。

光導波路用薄膜は本来、その中を伝播する光の波長のオーダーの厚みを有すれば良く、薄膜の厚さは光波長の0.1～100倍の範囲であることが

できるが、波長の1～1[illegible]範囲が良好である。光導波の実験は良く知られているプリズム光結合器により第2図の如くレーザー光を薄膜中へ導入して行うことができる。第2図において1は基板、2は光導波用エピタキシャル薄膜、3，3'はプリズム結合器、4はレーザー光である。この方法により光損失の値を求め薄膜の良否を判定することができる。

さて、上記ペロブスカイト型ABO_3結晶にエピタキシャル成長によりII−VI族半導体結晶薄膜を得る本発明の実施例を説明する。

(1) $SrTiO_3$上への$ZnSe$の蒸着

$SrTiO_3$の（100）面を基板として$ZnSe$単結晶を蒸発源として蒸着を行なった。基板温度は200℃～600℃まで変化させ、蒸着温度は800℃～1000℃で行なった。基板温度は400℃～500℃でかなり良好なエピタキシャル膜を得ることができ、光導波のテストでも損失は小さいものであった。

(2) $SrTiO_3$，$SrZrO_3$上への$ZnTe$の成長。

$SrTiO_3$の（001[illegible]を基板として第3図の如くの成長装置で気相成長させた。加熱炉中の石英管6中でZn，Teの原料7，8側の温度は490℃一定とし、Zn，Teガスの供給量はH_2ガス流量を変化させて行った。基板9の温度720℃、主H_2流量200cc/min，ZnとTeのキャリアガス流量50cc/minで行なった時、数千Åから100μ程の厚さの成長層を得た。成長層はX線及び電子線回折によって単結晶薄膜であることが確認されるとともに$SrTiO_3$結晶（001）面に$ZnTe$(100)が成長しており、光導波テストについても良好であった。また、$SrZrO_3$上へ$ZnTe$をエピタキシャルした場合若干$SrZrO_3$基体の結晶性が悪く、光導波テストでは上記に比して損失が大きかったがエピタキシャル成長薄膜が得られた。

(3) $SrTiO_3$上への$ZnSe_{1-x}Te_x$（$0<x<1$）の蒸着。

$SrTiO_3$の（100）面を基板として$ZnSe_{0.5}Te_{0.5}$を蒸発材料とし蒸着を行なった。条件は実施例(1)とほぼ同等であり、得られた膜は部分

的に単結晶化しており光導波テストでは(1)より損失は少し大きい値が得られた。xの範囲値は$ZnSe_{1-x}Te_x$混晶単結晶作製例と同等の値が得られる。

本発明は上記実施例のエピタキシャル方法にのみよらず、エピタキシャル方法としては液相，気相，分子線エピタキシャル，真空蒸着法などが適用できる。

本発明の光導波装置はII−VI族化合物半導体の持つ特性即ち一般に良く知られている電気光学効果を使用した第4，5図に示す光変調器，光スイッチあるいは光伝導性を使用する第6，7図のフォトディテクターなどを構成することができる。

第4，5図において、9はペロブスカイト型ABO_3単結晶基板、10は基板9上に成長されたII−VI族半導体単結晶薄膜、11，12はこの薄膜に不純物を拡散して形成された光導波路13，14，15は電極であって、この電極14に電源16より電圧を印加して第4，5図に示す光変調器が構成されており、薄膜11と12は方向性光

結合器を形成している。すなわち導波路11に入射された光17は電極への印加電圧より変調され導波路12より出力させる。

第6，7図において9，10，11は第4，5図と同一のものを示し、薄膜11と電極20，21とでショットキバリア形フォトダイオード部を構成している。22，23は引き出しリード線である。この装置は薄膜11を通ってきた光を上記フォトダイオード部で検出するものである。

以上のように本発明はII−VI族化合物半導体の薄膜をペロブスカイト型ABO_3結晶絶縁体基板上に形成可能となり、光導波のための光導波装置の作成を可能とするものであり、基板の選択や固溶体化により欠陥の少い結晶性の良好な薄膜単結晶ができ、それゆえ良好な薄膜光導波装置を得ることができる。すなわち、II−VI族結晶の高い電気光学効果により光変調器，光スイッチが作製出来、またショットキーバリヤ型の光検出器，ヘテロ接合型のフォトダイオードが同一基板上に可能となり、光通信のための信号処理部品として有益な装

置を供するものである。

4、図面の簡単な説明

第１図はＡＢＯ$_3$型結晶と半導体層とのエピタキシャル接合の方位関係図、第２図は光導波実験用プリズム光結合器の構造断面図、第３図は本発明の一実施例で使用する気相成長装置の概略構成図、第４図は本発明を応用した光変調器の平面図、第５図は第３図のⅢ－Ⅲ'線断面図、第６図は同じく本発明を応用したフォトディテクターの要部断面図、第７図は第６図のＶ－Ｖ'線断面図である。

９……ＡＢＯ$_3$ペロブスカイト型単結晶基板、１０，１１……Ⅱ－Ⅵ族化合物半導体単結晶薄膜。

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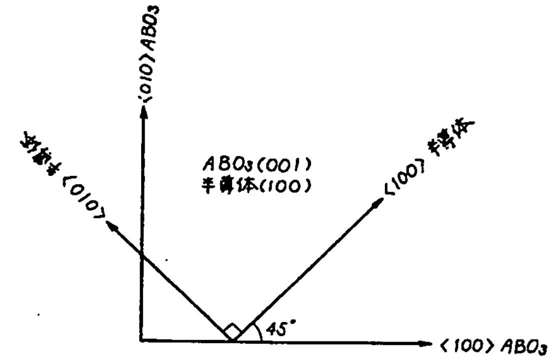
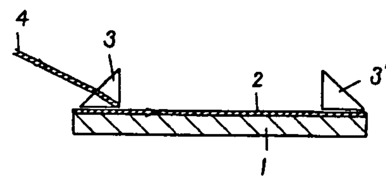
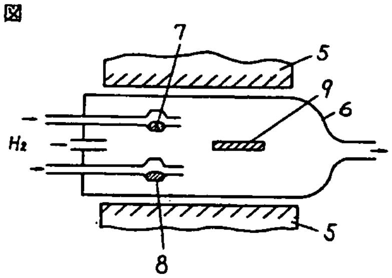
第１図



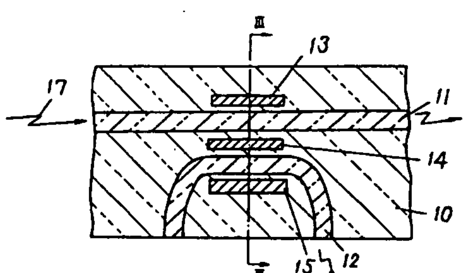
第２図



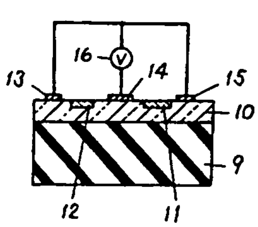
第３図



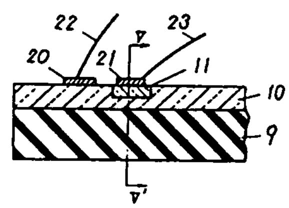
第４図



第５図



第６図



第７図